IEEE Std 929-2000 – Background, Implications and Requirements

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ABSTRACT

The newly revised standard, IEEE Std 929-2000, has significant positive implications for those designing inverters for utility-interconnected PV systems and for designers and installers of such systems. A working group of roughly 20 people, including PV systems designers/installers, PV inverter manufacturers and utility engineers spent close to 3 years developing a standard that would be useful and beneficial to all.

1. Introduction

IEEE standards are required to be reviewed every 5 years and either reaffirmed or revised. The previous IEEE PV/utility interconnection standard, IEEE Std 929-1988, was originally approved in 1988 and reaffirmed in 1991. In 1996, at the time of the next 5-year review, it was determined that a massive revision would best serve the interests of both the utility and PV communities. This decision was based on the fact that a growing number of utility-interconnected PV systems were being installed, and there was significant disparity between the interconnection requirements of many interconnecting utilities. It was felt that a single, widely accepted interconnection standard would result in consistent interconnection requirements across much of the country, which would allow PV inverter and PV system designers to standardize their designs.

Such standardization benefits PV system buyers by eliminating the expense associated with customized hardware for each installation. It benefits the PV system installer and the PV hardware manufacturer by allowing manufacture of one product that will fill a specific need in all locations. Standardization benefits the utility, the installer and the buyer by providing components that have been built and tested to a standard, thus reducing the probability of defective hardware.

It was also felt that this standardization would lead to cost savings. These savings would result from allowing inverter manufacturers to standardize on a single design, rather than having different designs for individual utility requirements. Also, a standardized interconnection requirement will eliminate the "soft" costs associated with the sometimes confusing and labor-intensive process of negotiating individual interconnection agreements with individual utilities. Finally, there would cease to be "surprises" when it came time to make the utility interconnection after the PV system is already installed.

It was recognized by the 929 working group that standardization may increase the cost of inverters in some cases, but the potential savings on the items listed above would far out weigh any additional costs associated with the inverter.

2. The Target Standard

At the beginning of the process several goals were established. Foremost was that the standard should be beneficial to both the PV and utility industries. All other goals followed from this one. These other goals included assuring that the PV system will not interfere with utility operation, and providing both the interconnecting utility and the PV system purchaser with a means to be certain that the PV system would be acceptable to the interconnecting utility before the system was installed.

The first of these goals, assuring that the PV system doesn't interfere with utility operation, includes requirements for power quality and safety. The most significant of the safety issues was the definition of a non-islanding inverter, and development of a technique to manufacture, and identify, a non-islanding inverter. A brief discussion of the non-islanding inverter development follows later in this paper.

The second of these goals, providing a method to be certain that the PV system would be acceptable to the interconnecting utility before the system was installed, was realized by a most fortuitous piece of cooperation with Underwriters Laboratories (UL). At the same time that IEEE 929 was being developed, UL took on the task of updating and finalizing UL 1741, the UL test procedure for PV inverters and charge controllers. UL agreed to include all the requirements of the revised IEEE 929 in the test regime for UL 1741. Thus a customer, or a utility, can check to see that the inverter for a PV system meets the requirements of the latest version (May 1999) of UL 1741, and be assured that it then meets the requirements of IEEE 929.

UL allows 18 months between when a new test standard is approved and when it <u>must</u> be used when testing a particular piece of hardware. Thus there is the possibility, until

November 2000, that an inverter can be designated as having passed UL 1741 when it has actually passed an earlier version of 1741 that doesn't include all the requirements of IEEE 929-2000. If there is some uncertainty regarding which version of UL 1741 an inverter has been tested to, one may contact UL directly to confirm which version of UL 1741 a particular inverter was tested to.[1]

3. What is Needed to Meet the Requirements of IEEE 929?

IEEE 929 sets requirements for the utility-interface device. That is, the energy source, the PV array, is not a factor in the standard. The only device that the standard impacts is that device where the utility-interface protection functions are accomplished – the inverter. Thus, the only requirement for meeting IEEE 929 is to use an inverter that is compliant with IEEE 929. Since UL 1741 tests for IEEE 929 compliant inverters, then use of a UL 1741 (May 1999 issue) listed inverter is the only requirement to assure 929 compliance.

Interestingly, since IEEE 929 does not impact the PV array, it is easy to envision that the energy source could be any of a number of other devices such as batteries or fuel cells, and the requirements of IEEE 929 wouldn't change. Thus IEEE 929 can be used as a model for utility interconnection of other energy sources in addition to PV.

4. A Complete Package

A PV system should be installed in a manner that assures the owner and the interconnecting utility that it is a safe system in all respects. This is particularly important in today's litigious society, and when homeowner's insurance is involved. The combination of IEEE 929, UL 1741, and the National Electrical Code (particularly Article 690) provides a complete package that allows safe and efficient installation of all aspects of utility interconnected PV systems. Furthermore, this package of standards will meet all interconnection requirements in those jurisdictions that have adopted IEEE 929. The list of states that are adopting IEEE 929 as the interconnection standard for PV systems is large and continues to grow.[2]

5. The Non-Islanding Inverter

One of the main concerns of utilities regarding distributed generation is islanding, or the inadvertent energization of a power line that should be de-energized. Islanding can be a significant safety concern, both for the utility line workers and for the public. In addition, islanding can interfere with the utility's normal procedures for bringing their system back into service following an outage. A more complete discussion of islanding and its implications can be found in [1].

To address the issue of islanding, a separate "Anti-Islanding Working Group" was formed at Sandia National Laboratories. This Working Group was composed mostly of representatives of inverter manufacturers, and tackled the development of an anti-islanding scheme that could be applied to any inverter manufacturer's product. The result of the work of this group was development of an active anti-islanding scheme that will result in multiple inverters all working in harmony to detect and de-energize an island.

<u>The Non-Islanding Inverter Test</u>

A key part of the work of the Anti-Islanding Working Group was development of a test procedure that will allow testing of a single inverter to determine if that inverter employs an adequate anti-islanding technique. Such a test was developed, using an RLC load tuned to 60 Hz as the key part of the test. This test, as well as the anti-islanding scheme, is thoroughly discussed in [1].

6. Additional Testing

While IEEE 929-2000 was being developed, there was significant activity in various states regarding interconnection standards. One of the most active was New York. (Two utility engineers from New York volunteered to serve on the 929 working group because of the high level of activity and these engineers desire to have 929 be a standard that could be adopted in New York.) As a result of the New York activity, some specific testing was done at the request of several of the utility engineers in New York. A set of waveforms that was measured during testing of distributed generators in New York during the late 1980's was used for testing. Because of the presence of these unusual waveforms, some conventional protective relays were unable to detect that the utility was experiencing abnormal conditions, and the relays did not remove the distributed generation from the lines. This experience resulted in a requirement in New York that all protective devices be tested to assure that they would perform as required in the presence of these waveforms. Several PV inverters were tested with these waveforms at Sandia National Laboratories, and they had no problem recognizing when there was an abnormal utility condition and disconnecting the inverter.

7. References

[1] Stevens, Bonn, Ginn, Gonzalez, Kern: "Development and Testing of an Approach to Anti-Islanding in Utility-Interconnected Photovoltaic Systems", SAND98-1684, Sandia National Laboratories.

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[1]The person to contact at UL at the time of this publication (April 2000) is the engineer in charge of UL 1741, Tim Zgonena. Tim can be reached at (847) 272-8800, ext. 43051, or at Timothy.P.Zgonena@us.ul.com

[2]An update of those states that have adopted IEEE 929 as their interconnection standard can be found on the Internet at www.irecusa.org, then clicking "Connecting to the grid".